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Infectious disease risk and international tourism demand

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Abstract

Context For some countries, favourable climatic conditions for tourism are often associated with favourable conditions for infectious diseases, with the ensuing development constraints on the tourist sectors of impoverished countries where tourism's economic contribution has a high potential. This paper evaluates the economic implications of eradication of Malaria, Dengue, Yellow Fever and Ebola on the affected destination countries focusing on the tourist expenditures.

Methods A gravity model for international tourism flows is used to provide an estimation of the impact of each travel-related disease on international tourist arrivals. Next the potential eradication of these diseases in the affected countries is simulated and the impact on tourism expenditures is estimated.

Findings The results show that, in the case of Malaria, Dengue, Yellow Fever and Ebola, the eradication of these diseases in the affected countries would result in an increase of around 10 million of tourist worldwide and a rise in the tourism expenditure of 12 billion dollars.

Conclusion By analysing the economic benefits of the eradication of Dengue, Ebola, Malaria, and Yellow Fever for the tourist sector—a strategic economic sector for many of the countries where these TRD are present—this paper explores a new aspect of the quantification of health policies which should be taken into consideration in future international health assessment programmes. It is important to note that the analysis is only made of the direct impact of the diseases' eradication and consequently the potential multiplicative effects of a growth in the GDP, in terms of tourism attractiveness, are not evaluated. Consequently, the economic results can be considered to be skeleton ones.

Keywords: Economic impact, global health, tourism, travel-related illness

Key Messages

- Favourable climatic conditions for tourism are often associated with favourable conditions for infectious diseases. It is possible to evaluate the economic implications of eradication of different Travel related Diseases using a gravity model and focusing on the tourist industry.
- Malaria, dengue, yellow fever and Ebola are significant determinants of international tourism flows.
- The eradication of malaria, dengue, yellow fever and Ebola would result in an impact of 12 billion dollars in terms of tourism expenditures.

Introduction

In 2014, over 1 billion international tourists travelled around the world, a figure that is expected to grow annually at a rate of 4% during the coming years (UNWTO, 2014). In economic terms, the travel and tourist industry accounts for 10.2% of the World Gross Domestic Product (WTTC 2014), a percentage that is often higher in less developed countries with favourable climate conditions. For many of these countries, tourism constitutes an important source of foreign exchange and income, which are expected to have positive repercussions on the general development of the country (Sharpley and Telfer 2002).

Nevertheless, favourable climate conditions for tourism often also imply favourable conditions for infectious diseases, with the ensuing development constraints on countries' tourist sectors. Although, in general, tourists are reluctant to travel to countries with different infectious diseases (Page 2009), trips to less developed countries with a prevalence of these diseases are still growing (Leder *et al.* 2013). Health problems are self-reported by 22–64% of travellers to the developing world and infectious diseases are frequently the most commonly perceived health risk for potential tourists when choosing a destination (Steffen *et al.* 2003).

Given the growing popularity of tourism trips to less developed countries and many impoverished nations' economic dependence on tourism, this paper aims to explore the relationship between the tourist industry and the presence of the most significant travel-related diseases (TRD). Using an aggregate perspective, the presence of Malaria, Yellow Fever, Dengue and Ebola is evaluated in destination countries, and the potential economic impact of the eradication of these TRD is estimated by focusing the analysis on international tourist arrivals. Despite the tourist sector's economic importance for many countries with warm climate conditions, plus potential tourists' sensitivity to the presence of some infectious diseases when choosing a destination and the relevance of health policies in less developed countries, to our knowledge this is the first time that a study of these characteristics has been undertaken.

Previous papers have explored the impact of some specific disease outbreaks on tourism. For instance, Kuo *et al.* (2008) investigate the impacts of infectious diseases including Avian Flu and severe acute respiratory syndrome (SARS) on international tourist arrivals in Asian countries. Their results indicate that the numbers of affected cases have a significant impact on SARS-affected countries but not on Avian Flu-affected countries. Similarly, McAleer *et al.* (2010) also study the impact of these two diseases on international tourist arrivals to Asia and, again, they obtain that SARS is more important to international tourist arrivals than is Avian Flu. Cooper (2006) analyses the reactions of the Japanese tourist industry towards SARS while Zeng *et al.* (2005) explore its impact for China. Regarding other types of diseases Blake *et al.* (2003) obtain that the foot and mouth disease (FMD) outbreak significantly reduced tourism expenditures in the UK. In general, this previous studies obtain a link between infectious disease and tourism although they are focused on a specific country or region.

The objective of this study is threefold: First, the association between the existence of TRD risk and international tourism movements is evaluated. To that end, a generalization of the gravity model for international tourism demand is defined, providing an estimation of the impact of each considered TRD on international tourism arrivals. Second, simulations of the potential eradication of these diseases at a national level, and so the disappearance of the risk of infection, were considered and evaluated. Finally, the impact of the diseases' eradication on the tourist demand was used to estimate the ensuing tourism expenditures and thus to provide a direct quantification of the benefits of different health policies in economic terms that could be compared with treatment costs in line to a strategy for implementing a global budget (Bishop and Wallack 1996; Bowser *et al.* 2014). Then, the novelty of this paper lies in providing an economic estimation of the impact of the eradication of the main travel-related disease risk of infection at a global scale.

The paper is organized as follows: 'Travel-related diseases and tourism' section briefly revised some papers that explore the effect of TRD on tourism; 'Methodology and data' section presents the data and methodology used; 'Impact of infectious disease risk on tourist arrivals' section discusses the results of the empirical analysis where the impacts of TRD risk on inbound tourism are estimated; 'Impact of eradication of TRD risk on tourism expenditure' section presents a simulation analysis where the effect of eradication of the infectious diseases are obtained and the impact on tourism expenditure is evaluated; 'Conclusion' section concludes.

Travel-related diseases and tourism

The growth in the number of international tourist flows reflects the rapid movement of large population groups, which may pose an increased risk of travel-related illnesses, particularly communicable diseases. Poor socioeconomic conditions, inadequate sanitation and cultural differences between the travellers' countries of origin and their travel destinations all contribute to this increase (Abdullah *et al.* 2000). The most common reasons why tourists seek medical care tend to be for gastrointestinal illnesses, fevers and skin disorders (Gautret *et al.* 2009) and it has been found that 30% of tourists had to seek medical attention for colds, nausea, stomach upsets and diarrhoea while visiting tropical islands (Pearce 1981) and that 62% of tourist visits to tropical island nursing clinics were due to respiratory, digestive, skin/eye and genitourinary disorders (Wilks *et al.* 1995). In the case of Australians travelling abroad it has been shown that infectious disease the cause a 2.4% of death (Schmierer and Jackson 2006). Although tourist ignorance and carelessness are often the cause of these real risk situations, the perceived risk of disease clearly affects tourist behaviour, especially in their choice of tourist destination.

Turning to the effects of disease on destinations, the recent avian flu and severe acute respiratory syndrome (SARS) epidemics are good examples of outbreaks that have had a big media impact with important health policy controversies in recent years (Pongcharoensuk *et al.* 2012). A drop of 12 million arrivals to Asian and Pacific countries following the outbreak of the avian flu epidemic has been estimated (Wilder-Smith 2006). The World Travel and Tourism Council estimated that approximately 3 million people in the tourist industry lost their jobs following the SARS outbreak in the most severely affected countries of China, Hong Kong, Vietnam and Singapore, resulting in losses of over $20 billion (WTTC 2003). Another example of a temporary disease with significant effects on tourism was the impact of foot and mouth disease on tourist expenditures in the UK (Blake *et al.* 2003). Among the study's key findings, tourism revenue in 2001 fell by almost £7.5 billion and some 21% of this amount was attributable to a fall in domestic tourism, with Scotland and London being the UK's hardest hit areas. Scotland experienced a fall of £2 billion, equivalent to 27% of the total UK drop in tourist expenditure, while London saw a drop of £1.25 billion; that is, 16.8% of the total UK decrease in tourist expenditure.

However, aside from temporary episodes of epidemic diseases that have made the news in recent years, different endemic TRD are also acknowledged to influence the destination chosen by millions of tourists each year. Malaria and Dengue are the most prevalent pathogens among ill returned travellers; diseases that could probably be combated through specific health policies to eradicate them (Freedman *et al.* 2006), Malaria has been identified as the most common specific diagnosis in ill returned patients with a systemic febrile illness (Gautret *et al.* 2009), and Sub-Saharan African and Indian Ocean islands have been highlighted as a major source of Malaria among European ill returned patients. According to the World Health Organization (WHO), globally, an estimated 3.3 billion people are at risk of being infected with Malaria or of developing a disease, with 1.2 billion being at high risk (WHO 2014). For all these reasons, Malaria is the first TRD analysed in this paper.

Dengue is now also considered to be one of the major causes of fever in ill returned travellers who may even serve as important sentinels of new outbreaks of Dengue in Dengue-endemic areas. The Dengue virus is the second most commonly identified pathogen responsible for fever, particularly in patients returning from Southeast Asia. The incidence of Dengue has been considered to be higher than that of other so-called typical travel-related diseases, such as vaccine-preventable hepatitis A and typhoid fever (Gautret *et al.* 2009). Consequently, Dengue is also analysed in our study.

Another of the most important diseases considered in this paper, in terms of the risk to travellers, is Yellow Fever. A traveller's risk of catching Yellow Fever is determined by various factors, including their immunization status, travel location, the season, the length of exposure, occupational and recreational activities while travelling, and the local rate of virus transmission at the time of travel. Although reported cases of human disease are the main indicator of the disease risk, case reports may be missing due to low transmission levels, a high level of immunity in the population (because of vaccinations, for example), or the failure of local surveillance systems to detect cases (WHO 2012).

Finally, in addition to Malaria, Dengue and Yellow Fever, Ebola is also chosen for the economic analysis in this paper because of its media impact during 2014 and 2015. It should be noted that, in 2014, airlines suspended flights to Ebola-hit African countries, a key component of the tourist sector, and various promising candidate vaccines have been assessed. The effect of the Ebola crisis on travel and tourism is being felt across the whole of Africa, more than in almost any other sector, due to the heightened perceived risk of travel (Nyarko *et al.* 2015). The major impact will be through the demand side; that is, discretionary spending in the form of travel and tourism, with international tourism being hit the most and also domestic tourism. In the event of the spread of Ebola, the World Bank has noted that the output forgone due to Ebola in 2015 alone in the three countries is estimated to account for more than $1.6 billion, over 12% of their combined GDPs (World Bank Group 2015).

Methodology and data

Methodology

Different techniques have emerged during recent decades, aimed at evaluating the economic impacts of infectious diseases. Methods proposed in the literature that measures the economic impact of vector-borne diseases at country level can be classified into micro-based and macroeconomic approaches (Basili and Belloc 2015). On the one hand, micro-based methods are founded on individual or household specific measures of the economic effects of a disease, which are then aggregated at a national level. It is argued that micro-based measures tend to underestimate the true economic impact of infectious diseases, because they do not capture a number of macroeconomic factors and externality effects (Sachs and Malaney 2002; Bloom and Fink 2014).

On the other hand, macroeconomic approaches follow a traditional cross-country perspective, in which variations in economic outcome variables at country level are explained as a function of variations in population health repressors. However, due to the two-way causality between economic outcomes and infectious disease incidence, this perspective suffers from endogeneity problems (Acemoglu and Johnson 2007). In other words, health status influences people's absolute and relative income levels, while, in turn, economic status is a determinant of health. For both categories, there are additional evaluation problems, such as how to handle future benefits and costs, particularly long-term effects, and whether and how to discount future effects.

Within an aggregate framework, time series models are presented as a suitable methodology when the effects of transitory epidemic diseases have to be evaluated (Min 2005; Kuo *et al.* 2008; Wang 2009; Rossello 2011). Then, an autoregressive moving average model, sometimes together with an exogenous variables, can be used to estimate the effects of these diseases in each SARS and avian flu-infected country. The incidence of the illness is introduced in the model using dummy variables during the periods of the illness incidence. However, time series models are probably not the most suitable tool when the effect of a relatively stable variable has to be evaluated, and this could be the case here, where the presence (or incidence) of a certain disease in a country is expected to present a low level of variability over the years.

Because the aim of this paper is to evaluate the effect of TRD on tourism and because these determinants are expected to have a high structural component, a gravity equation is used to explain tourism flows, while also considering the potential time variability of the determinants. The gravity equation method suggests that different international flows (i.e. trade, tourism, migrations, foreign direct investment etc.) are expected to increase with the economic size of a country and to decrease as the distance between country pairs grows. Additionally, a set of other determining variables, such as the presence of diseases at the destination, can also be included. From a methodological point of view, in comparison with other studies that evaluate the economic impact of health policies, by focusing the analysis on the tourist sector, the endogeneity problem often pointed out in similar economic studies is avoided. Thus, although it is easy to believe that health status influences tourist arrivals to a certain country, it is more difficult to believe that tourist arrivals are a determinant of health in this country.

This framework has been extensively used for empirical exercises due to its goodness of fit, above all to explain international trade (Deardorff 1998; Anderson and Wincoop 2003). Since tourism is considered to be a special type of trade in services, gravity equations have also been used to estimate the magnitude of tourism flows in different contexts (Eilat and Einav 2004; Kimura and Lee 2006; Santana-Gallego *et al.* 2010; Fourie and Santana-Gallego 2011; Falk 2016). Although the application of the gravity equation method has been supported by the international trade theory for many years, only recently the use of a gravity equation has recently justified in the context of tourism by the use of the consumer theory (Morley *et al.* 2014).

Model and data

From previous literature, the model considered in this paper can be defined as:

$$\begin{aligned}\mathrm{LnTou_{ijt}} = {} & \beta_0 + \beta_1 \mathrm{LnGDPpc_{jt}} + \beta_2 \mathrm{Pop_{jt}} + \beta_3 \mathrm{LnDist_{ij}} + \beta_4 \mathrm{Border_{ij}} \\ & + \beta_5 \mathrm{Lang_{ij}} + \beta_6 \mathrm{Colony_{ij}} + \beta_7 \mathrm{Comcol_{ij}} + \beta_8 \mathrm{Smctry_{ij}} \\ & + \beta_9 \mathrm{ReligSim_{ij}} + \beta_{10} \mathrm{RTA_{ijt}} + \beta_{11} \mathrm{RLaw_{jt}} \\ & + \beta_{12} \mathrm{Terrorism_{jt}} + \beta_{13} \mathrm{WHS_j} + \beta_{14} \mathrm{LnTemp_j} \\ & + \beta_{15} \mathrm{LnLifeExp_{jt}} + \gamma' \mathrm{DiseaseRisk_j} + \lambda_{it} + \varepsilon_{ijt}\end{aligned} \tag{1}$$

The dependent variable *Tou* is the number of international tourist arrivals from country of origin *i* to destination country *j* during year *t*. The dataset includes 208 origin countries and 196 destination countries for the period 2000–2013. For a total of 40 365 possible country pairs, there exist positive tourism flows, with missing values, for 14 119 (35%).[1]

The explanatory variables are defined as follows. *GDPpc* is the per capita real gross domestic product of the destination country; *Pop* is the population of the country of destination; *Dist* is the distance in kilometres between country of origin and destination country; *Border, Lang*, *Colony Comcol* and *Smctry* are dummy variables that take a value of one if both countries in the pair share a common geographical land border, a common language, a colonial background, and common colonizer and have been part of the same country respectively, and zero otherwise; *ReligSim* is a religious similarity index as defined by Fourie *et al.* (2015)[2]; RTA is a dummy variable for being a signatory to the same regional trade agreement; Rlaw is a proxy for the quality of the institutions at the destination country[3]; Terrorism is a proxy for the instability and insecurity at the destination country measured as the number of victims in terrorist attacks per 10 000 inhabitants; WHS is the number of World Heritage Sites (WHS) at the destination country, Temp is the average annual temperature in the destination country[4]; *LifeExp* is the life expectancy at birth in the destination country. Finally, ε is a well-behaved disturbance term.

It should be noted that, as in similar exercises, the *Tou*, *Dist*, *GDP, Pop, Temp and LifeExp* variables are taken in natural logs (Ln), aiming to reduce heteroscedasticity and to capture any nonlinear relationship between these variables. Therefore, these coefficients can be interpreted as elasticities.[5]

The variable of interest is *DiseaseRisk* that includes a set of key travel-related diseases, namely Malaria, Dengue, Yellow Fever and Ebola. This variable is a dummy variable with value of unity when there exist disease risk in the destination country, and zero otherwise. This set of variables reflects the existence of a TRD risk of contagion for travellers when visit a particular country. It is important to mention that in the present research it is assumed that the key factor in the impact of infectious diseases on tourism is the existence of the disease in the destination country (and not prevalence ratio per year). Therefore, it is considered that tourists mainly focus on the existence of a moderate or high risk of contagion when they travel to a destination country, as opposed to the real number of cases. In particular, it is considered travel warnings about risk of contagion for travellers and these risks remains constant for the whole period under analysis (2000–2013). Even if a particular country does not experience any disease case, if it has existed in the past it can still present risk of contagious.

Consequently, WHO recommendation for travellers regarding Yellow Fever vaccinations and details concerning the risk of Malaria per country (risks C and D) are used.[6] This data are completed with information from the Center for Disease Control and Prevention (CDC 2016). Specifically, in the CDC's Health Information for International Travel (commonly known as the Yellow Book), health risk levels for international travellers to different countries are published.[7] Moreover, for Dengue and Ebola risk it has been considered countries where Dengue is Endemic and there exists a risk of infection and countries that have experience Ebola outbreaks in the past. In the empirical analysis, the following data on infectious diseases are considered: (i) the estimated moderate or high risk of Malaria for travellers[8]; (ii) Dengue risk areas where the disease is endemic, implying a high risk of contagion for travellers[9]; (iii) countries where a Yellow Fever vaccination is recommended before travelling there[10]; (iv) countries with Ebola outbreaks since 2000; (v) risk of any disease is also considered since one country can present more than one type of TRD risk.

The variables of interest, namely, *DiseaseRisk*, is a vector of destination-specific time-invariant characteristic, so panel estimation techniques cannot be applied since the variable of interest would be dropped. Origin country time-varying fixed effects (λ_{it}) are included to control for source country characteristic such as population or GDP per capita of the origin country. However, destination time varying (or, alternatively destination fixed effects and year fixed effects) cannot be included since they would not allow to estimate the variable of interest. Therefore an extensive set of destination and country-pair controls are included in the regression. Consequently, Equation (1) is estimated by pooled OLS including time-varying source country dummy variables (origin-year) fixed effects where standard errors are clustered on host/source country pairs. Table 1 presents some descriptive statistics.

Impact of infectious disease risk on tourist arrivals

According to Morley *et al.* (2014) the introduction of the time-dimension on tourism demand makes possible to evaluate not only the structural nature of the determinants but also its dynamic

Table 1. Descriptive statistics

	Obs	Mean	SD	Min	Max
$LnTou_{jt}$	142 415	6.918	3.277	0.00	18.18
$LnGDPpc_{jt}$	142 415	8.488	1.447	4.91	11.36
$LnPop_{jt}$	142 415	16.052	2.040	9.86	21.06
$LnDist_{ij}$	142 415	8.492	0.954	2.35	9.90
$Border_{ij}$	142 415	0.038	0.191	0.00	1.00
$Language_{ij}$	142 415	0.190	0.392	0.00	1.00
$Colony_{ij}$	142 415	0.020	0.140	0.00	1.00
$Comcol_{ij}$	142 415	0.106	0.308	0.00	1.00
$Smctry_{ij}$	142 415	0.018	0.133	0.00	1.00
$ReligSim_{ij}$	142 415	0.190	0.235	0.00	0.99
RTA_{ijt}	142 415	0.191	0.393	0.00	1.00
$Rlaw_{jt}$	142 415	0.108	0.930	−1.95	2.00
$Terrorism_{jt}$	142 415	0.008	0.050	0.00	2.14
WHS_{jt}	142 415	7.063	9.622	0.00	53.00
$LnTemp_{jt}$	142 415	2.768	0.565	0.41	3.34
$LnLifeExp_{jt}$	142 415	4.262	0.127	3.71	4.43
$Malaria_{jt}$	142 415	0.147		0.00	1.00
$YellowFever_{jt}$	142 415	0.146		0.00	1.00
$Dengue_{jt}$	142 415	0.325		0.00	1.00
$Ebola_{jt}$	142 415	0.006		0.00	1.00
$AnyTRD_{jt}$	142 415	0.388		0.00	1.00

evolution. However, since travel warnings about risk of contagion remains constant for the whole period, tourist arrivals to countries with and without a disease risk are being compared. Therefore, in this section the short-run effect of eradication of a TRD is not evaluated but the impact of its existence on the urists' destination choice. In general, it is expected that if there exist risk of infection/contagion when travelling to a particular country, tourist will choose an alternative destination with none or low risk. Consequently, a negative estimated coefficient for *DiseaseRisk* is expected.

Table 2 presents the estimated coefficients and different regression statistics for the five estimated equations [Equation (1)], one for each considered TRD, i.e. Malaria, Dengue, Yellow Fever, Ebola and any TRD. From a medical point of view, policy and measures taken to eradicate each of these diseases can be different and, consequently separate equations to evaluate each of the diseases is estimated. Moreover, from an econometric point of view, when a joint estimation is carried out the high correlation between countries affected by different diseases gives non-expected results or non-significance for some of the diseases.

Equation (1) is estimated by pooled OLS including origin-year fixed effects. The R-square values in Table 2 for all the disease equations show that a 77% variation in international tourist arrivals has been explained. In general, the estimated parameters yield the expected signs and sizes, suggesting that the model is correctly specified. Estimate parameters are very similar in the four regressions for each disease risk under analysis.

The per capita GDP and population of the destination countries are significantly positive suggesting that tourists prefer travelling to richer and populated countries. The distance variable, which can be regarded as a proxy for the cost of the trip, is consistently negative

Table 2. Effect of TRD Risk on international tourist arrivals (Pooled OLS 2000–2013)

	(A)	(B)	(C)	(D)	(E)
$LnGDPpc_{jt}$	0.405***	0.491***	0.452***	0.463***	0.404***
	(0.0191)	(0.0186)	(0.0183)	(0.0183)	(0.0184)
$LnPop_{jt}$	0.673***	0.664***	0.656***	0.658***	0.650***
	(0.0101)	(0.00998)	(0.01000)	(0.00996)	(0.00990)
$LnDist_{ij}$	−1.316***	−1.290***	−1.295***	−1.300***	−1.282***
	(0.0234)	(0.0235)	(0.0235)	(0.0233)	(0.0235)
$Border_{ij}$	1.221***	1.269***	1.243***	1.244***	1.263***
	(0.120)	(0.121)	(0.122)	(0.122)	(0.121)
$Language_{ij}$	0.875***	0.886***	0.875***	0.872***	0.900***
	(0.0442)	(0.0443)	(0.0445)	(0.0444)	(0.0441)
$Colony_{ij}$	0.785***	0.774***	0.783***	0.789***	0.766***
	(0.113)	(0.114)	(0.115)	(0.114)	(0.115)
$Comcol_{ij}$	0.474***	0.419***	0.454***	0.453***	0.468***
	(0.0630)	(0.0634)	(0.0631)	(0.0633)	(0.0627)
$Smctry_{ij}$	0.0918	0.135	0.0910	0.0863	0.134
	(0.142)	(0.143)	(0.144)	(0.144)	(0.143)
$ReligSim_{ij}$	1.080***	1.122***	1.102***	1.092***	1.134***
	(0.0659)	(0.0663)	(0.0663)	(0.0663)	(0.0658)
RTA_{ijt}	0.747***	0.769***	0.777***	0.773***	0.777***
	(0.0439)	(0.0440)	(0.0441)	(0.0439)	(0.0440)
$Rlaw_{jt}$	0.539***	0.414***	0.466***	0.467***	0.472***
	(0.0255)	(0.0261)	(0.0249)	(0.0249)	(0.0248)
$Terrorism_{jt}$	−2.059***	−2.260***	−2.225***	−2.146***	−2.378***
	(0.237)	(0.238)	(0.239)	(0.239)	(0.239)
WHS_{jt}	0.0202***	0.0178***	0.0192***	0.0189***	0.0197***
	(0.00195)	(0.00201)	(0.00199)	(0.00200)	(0.00197)
$LnTemp_{jt}$	0.735***	0.711***	0.709***	0.662***	0.854***
	(0.0294)	(0.0296)	(0.0325)	(0.0290)	(0.0336)
$LnLifeExp_{jt}$	−0.781***	−0.302**	0.185	0.127	0.0208
	(0.162)	(0.152)	(0.154)	(0.155)	(0.152)
$Malaria_{jt}$	−0.629***				
	(0.0531)				
$YellowFever_{jt}$		−0.445***			
		(0.0406)			
$Dengue_{jt}$			−0.124***		
			(0.0343)		
$Ebola_{jt}$				−0.324*	
				(0.187)	
$AnyTRD_{jt}$					−0.464***
					(0.0373)
Observations	142 415	142 415	142 415	142 415	142 415
R-squared	0.770	0.770	0.768	0.768	0.766

Notes: Robust standard error clustered by host/source country pairs in parentheses. Constant and origin-year fixed effects are not reported.
***$P < 0.01$,
**$P < 0.05$,
*$P < 0.1$.

and significant. This result is also confirmed by the significantly positive effect of the common border dummy variable, suggesting that tourists prefer to travel to closer countries. Cultural factors such as colonial links, sharing a common language or a religious similarities display significantly positive coefficients in the estimates. Hence, a cultural gap is a relevant explanatory factor in international tourism demand. As expected, countries with coast (or not being a landlocked country) have a positive effect on the number of tourist arrivals. Being member of a common regional trade agreement, used as a proxy for the intensity of the economic relations between countries yields a positive effect.

Destination specific characteristics such as the rule of law and number of fatalities in terrorist attacks per 10 000 inhabitants present the expected signs. That is, tourists prefer travelling to safer countries and with a higher quality of their institutions. Finally, variables that might affect the tourist attractiveness of the destination are significant and with the expected sign. A higher annual average temperature and the number of World Heritage Sites at the destination country have a positive effect on tourist arrivals. The estimated impact of life expectancy at birth differs depending on the disease risk considered in the regression, although it is not significant in three of the five models estimated.

As for the variable of interest, all the parameters related to TRD are significant and show negative signs, evidencing the expected negative relationship between the existence of the disease and the level of tourist arrivals. That is, countries with a TRD risk, receive a lower number of international tourists. In particular, countries with Malaria risk receive 47% fewer tourists than countries where this disease is not endemic.[11] Similarly, countries with Yellow Fever receive 36%, while countries with a risk of Dengue and Ebola receive 12% and 28% fewer tourists, respectively. Observing the parameter of the variable of having risk of any TRD, it is also significantly negative implying that countries with TRD risk receive 37% fewer inbound tourists. Therefore, it seems clear that TRD risk implies a barrier for tourism sector to develop since the risk of infection is taken into account when people decide the tourist destination. Moreover, Malaria is the TRD that presents the highest impact on tourism.

There are reasons to assume that travellers from highly developed countries are more sensitive to these diseases, than tourist from developing countries. Therefore, the impact of TRD risk on different subsamples of origin countries is explored as a robustness check. The sample is disaggregated by level of development of the origin countries using the Human Development Index (HDI). Therefore, Developed countries (114) are countries that present very high or high HDI while developing countries (94) are countries with medium or low HDI. Table 3 presents results of the impact of TRD on inbound tourism according to the development level of the origin country.

It is observed how the impact of Malaria, Yellow Fever and Ebola is larger when tourists arrive from developed countries while the opposite happens for Dengue. Interestingly, Dengue risk is not significant for tourist arrivals from developed countries while Ebola risk is not significant for tourist arrivals from developing countries. To sum up, it can be generally concluded that tourists from developed countries, where TRD are eradicated, are more sensitive to infectious diseases risk when they decide the tourist destination.

Impact of eradication of TRD risk on tourism expenditure: simulation analysis

In this section, the direct economic impact of eradicating a TRD risk is calculated. In a first stage, predicted tourism gains of removing a TRD risk are obtained. First, the predicted gains of tourist arrivals due to the eradication of each disease risk are obtained. Then, a counterfactual model is estimated considering that the TRD risk does not exist in any country, and predicted tourist arrivals are generated.[12] Finally, predicted total tourist arrivals from the baseline model and the counterfactual model are compared to obtain gains, in terms of inbound tourism, due to the complete eradication of a disease risk. It should be noted that the total number of arrivals to a particular destination can be obtained as the sum of tourist arrivals from all origin countries as $\widehat{TOU_j} = \sum_i \widehat{Tou_{ij}}$.

Table 3. Effect of TRD Risk by group of origin development level

	$Malaria_{jt}$	$YellowFever_{jt}$	$Dengue_{jt}$	$Ebola_{jt}$
Developed	−0.738***	−0.511***	0.0161	−0.468***
(114 countries)	−0.0643	−0.0489	−0.0421	−0.143
Developing	−0.409***	−0.331***	−0.402***	−0.316
(94 countries)	−0.0874	−0.0686	−0.0562	−0.435

Notes: Robust standard error clustered by host/source country pairs in parentheses. Complete estimates are available upon request.
$^{***}P < 0.01$.

In a second stage, we quantify the impact of the increase in total tourist arrivals to a particular country where there exists a disease risk. This assessment of the economic consequences of the TRD eradication is obtained assuming that there is a linear relationship between the total number of inbound tourists and tourist expenditure by foreign tourists in a destination country. Analytically, this is done by estimating the following equation:

$$\mathrm{Ln}EXP_{\mathrm{jt}} = \varphi_0 + \varphi_1 \mathrm{LnTOU}_{\mathrm{jt}} + \omega_t + \upsilon_j \qquad (2)$$

Where EXP is the total tourism expenditure by foreign tourists in a destination country j during period t; TOU is total international tourist arrivals in destination j at year t; ϕ_1, is the parameter to be estimated; ω_t is year fixed effects; and υ_{jt} is a well-behaved disturbance term. This simple model presented in Equation (2) is estimated for the 196 destination country for the period 2000–2013 using panel fixed effects. Total tourist expenditure EXP (in US$) is defined as expenditures by international inbound visitors, including payments to national carriers for international transport. Variables EXP and TOU are obtained from the World Development Indicators (The World Bank Group 2016).

At this point, it is important to point out that through this procedure only the direct effect of the eradication of travel-related diseases is obtained. Thus, it could be argued that an increase in tourism expenditures (receipts) in the destination country could increase GDP in that country and, as expressed in Equation (1), the GDP at the destination could act in itself as an attractor of international tourists (in the sense that a higher GDP could also be related to higher levels of development, public services etc., which might attract more tourists). Thus the multiplying effects of an increase in the GDP on tourism are not considered in this study. Moreover, displacement effects are also not considered in this analysis.

A specific reference year is not going to be considered to calculate the impact on tourist arrivals and tourist expenditure of a TRD eradication but the average for the period 2005–2008. This year span is selected because is the period before the world economic crisis.[13] For the simulation analysis, Equation (1) is re-estimated as a cross-section for the average values for 2005–2008 and results are presented in Table 4. As can be observed, estimate parameters are similar to the ones presented in Table 2. In particular, countries with risk of Malaria presents 48% fewer inbound tourism, with risk

Table 4. Effect of TRD Risk on international tourist arrivals (Cross-section average 2005–08)

	(A)	(B)	(C)	(D)	(E)
$Malaria_{jt}$	−0.649***				
	(0.0573)				
$YellowFever_{jt}$		−0.484***			
		(0.0461)			
$Dengue_{jt}$			−0.0750**		
			(0.0372)		
Ebola_{jt}				−0.592***	
				(0.213)	
$AnyTRD_{jt}$					−0.444***
					(0.0414)
Observations	12 106	12 106	12 106	12 106	12 106
R-squared	0.791	0.792	0.790	0.790	0.792

Notes: Full estimates available upon request. Robust standard errors clustered by host/source country pairs in parentheses.
$^{***}P < 0.01$.

Table 5. Relationship between tourists arrivals and tourist GDP

	LnExp_{jt}
LnTOU_{jt}	0.692***
	(0.025)
Observations	2310
Within R-squared	0.6354

Notes: Estimate by panel fixed effect. Constant and year fixed effects are not reported. Robust standard errors in parentheses.
$^{***}P < 0.01$.

of Yellow Fever a 39%, with Dengue risk a 7% and with Ebola risk a 45%. Moreover, having any type of TRD risk implies a decrease of tourist arrivals of 36% than countries without any disease risk.

The estimated Equation (2), linking international tourism and the tourism expenditures, is presented in Table 5. The high level of the R-square shows that tourism arrivals are a good predictor of the tourism expenditures in the destination countries. Therefore, this result confirms the link between the international tourism demand and the economic impact in the destination countries. The estimated parameter of the tourist flow variable shows that a 1% increase in tourist arrivals to a representative country implies a 0.69% increase in the tourist expenditures.

The simulated effects of the eradication of any TRD on tourism arrivals and tourist expenditure are presented in Table 6 while Tables S2–5 present the direct economic effect of eradicating Malaria, Yellow Fever, Dengue and Ebola, respectively. In this section, we are focusing on the effect of eradicating all TRD risks, since more than one infectious disease might exist in a country. However, the results presented in the Supplementary data are relevant for policymakers when they are evaluating the economic impact of eradicating a specific TRD. In any case, this estimate are for guidance only since, as previously mentioned, only direct effects are taken into account as well as displacement/substitution effects are not quantify. For instance, eradicating Ebola in Uganda would suppose an increase on inbound tourism but also can positively or negatively affect tourist arrivals to neighbouring countries like Tanzania or Kenya without Ebola risk.

The first two columns in Table 6 present predicted total tourist arrivals with TRD risk (benchmark) and without TRD risk (counterfactual). Third and fourth columns present increases in inbound tourism figures if TRD risk is eradicated, in thousands and in percentage change, respectively. In the fifth column, total tourist receipts in each country are presented, while last column presents the predicted gains in terms of tourism expenditure if all TRD are eradicated. For instance, is TRD are eradicated, tourist arrivals are expected to increase a 15.3% in Angola which implies an increase on tourist receipts of 19.1 million of US$ per year (=0.153*0.69*180)

One of the most remarkable outcomes is that there is a predicted increase of 10.6 million tourist arrivals (14.4%) after TRD are eradicated from the countries listed in the table, leading to a rise in tourism expenditures of 12 billion US$ worldwide. Specifically, countries in the Americas such as Aruba, Bahamas and Barbados are the ones that would see the highest growth in tourist arrivals. Countries whose tourist sectors have a higher level of tourism expenditures, like Thailand, Malaysia, Mexico and India would largely benefit from the eradication of Malaria.

On the other hand, African countries would experience very low or even negative (i.e. in Niger, Mali, Burkina Faso and Central African Republic) gains in inbound tourism if TRD risk disappear. This can be explained since the African countries suffer from several TRD risks which make the problem more complex as well as from very important structural barriers that impede the tourism sector to develop.

Conclusion

Literature shows that health and macroeconomics are strongly correlated, as good health in a population improves the country's economic outcomes, since it boosts economic wellbeing through higher levels of labour productivity, education and investment, and through demographic change. However, all these issues are often observed in the long run, jointly with the improvement of health statistics, and in many cases it is hard to establish the true causal relationship. Countries' resources are limited, and decisions have to be made in the short run as to whether investing resources in an eradication programme is preferable to their use in projects unrelated to healthcare or even in alternative health intervention programmes.

Using a gravity model, this paper has evaluated the effects of the eradication of Malaria, Yellow Fever, Dengue and Ebola on international tourism arrivals and its national economic impact at destinations through their tourist industries. This is the first empirical attempt to study the association between infectious disease risk and international tourism flows using a global database. However, since the variable of interest is time-invariant, causal effects cannot be explored.

The results show Malaria and Yellow Fever to be the diseases that play the most decisive role in explaining tourist destination choices. In any case, the risk of TRD is associated to a decrease of 37% in inbound tourism figures.

In this research, a simulation analysis to explore the impact on tourist arrivals and expenditure of eradication of infectious disease risks is implemented. As mentioned before, the figures presented are for guidance only but can help to evaluate one dimension of the impact of policies that aim to eradicate TRD.

Specifically, the eradication of Malaria can be associated with an increase of 6.2 million tourists and 3532 million US dollars in the affected countries per year, figures that represent an average 19.8% growth in total tourist arrivals of the affected economies. In the case of Dengue, its eradication would imply an increase of 2.5 million tourists, an increase in expenditure of 2861 million US dollars, and

Table 6. Effects of all disease eradication on tourism and tourism expenditure

	Predicted tourism With Disease Risk (thousands)	Predicted tourism without Disease Risk (thousands)	Tourism Increase (thousands)	Tourism Increase (%)	Tourist Expenditure (million US$)	Impact on Tourist Expenditure (million US$)
Africa						
Angola	123.3	142.2	18.9	15.3%	180	19.08
Benin	1114.8	1153.2	38.5	3.5%	170	4.05
Burkina Faso	958.3	921.1	−37.2	−3.9%	61	−1.63
Cabo Verde	358.8	445.4	86.5	24.1%	318	52.84
Cameroon	761.1	786.2	25.2	3.3%	220	5.03
Central African Rep.	77.8	74.8	−3.0	−3.8%	10	−0.27
Chad	139.3	141.2	1.9	1.4%		0.00
Comoros	214.9	240.0	25.1	11.7%	30	2.37
Congo	3047.3	3472.1	424.8	13.9%	46	4.46
Congo, Dem. Rep.	6734.6	7082.3	347.7	5.2%	2	0.07
Cote D'ivorie	453.1	461.1	8.0	1.8%	111	1.35
Eritrea	76.2	76.6	0.4	0.5%	58	0.22
Ethiopia	301.5	305.5	4.0	1.3%	790	7.15
Gambia	285.1	302.7	17.6	6.2%	74	3.15
Ghana	714.9	765.0	50.1	7.0%	935	45.23
Guinea	329.2	318.1	−11.1	−3.4%	2	−0.04
Guinea-Bissau	53.9	57.1	3.2	5.9%	18	0.71
Kenya	737.0	746.7	9.7	1.3%	1268	11.47
Madagascar	120.4	126.4	6.0	5.0%	453	15.68
Mali	977.7	933.2	−44.5	−4.6%	213	−6.68
Mauritius	1136.7	1511.4	374.6	33.0%	1500	341.12
Mozambique	258.0	277.0	19.0	7.3%	170	8.62
Niger	582.7	549.1	−33.6	−5.8%	53	−2.12
Nigeria	1941.4	2114.3	172.9	8.9%	413	25.35
Rwanda	534.7	567.8	33.1	6.2%	154	6.59
Senegal	1606.5	1653.0	46.6	2.9%	480	9.60
Seychelles	701.9	927.2	225.3	32.1%	350	77.52
Sierra Leone	156.8	159.3	2.5	1.6%	36	0.39
Sudan	375.5	398.7	23.2	6.2%	250	10.64
Tanzania	868.0	895.9	27.9	3.2%	1083	23.99
Togo	527.3	538.3	10.9	2.1%	33	0.47
Uganda	746.0	765.0	18.9	2.5%	418	7.31
Zambia	525.7	568.2	42.5	8.1%	125	6.94
Zimbabwe	194.4	201.5	7.1	3.7%	275	6.93
Americas						
Antigua & Barbuda	1047.1	1386.2	339.0	32.4%	328	73.17
Argentina	1939.4	2460.1	520.7	26.8%	4350	805.78
Aruba	1204.7	1642.1	437.4	36.3%	1200	300.64
Bahamas	491.0	663.1	172.1	35.0%	2150	519.91
Barbados	2529.4	3418.6	889.2	35.2%	1175	285.00
Belize	99.5	118.2	18.7	18.8%	260	33.66
Bolivia	194.5	210.1	15.6	8.0%	328	18.09
Brazil	1637.0	1959.8	322.8	19.7%	5050	687.11
Colombia	1724.2	1938.3	214.0	12.4%	2450	209.85
Costa Rica	1330.0	1568.9	238.9	18.0%	2100	260.24
Cuba	250.9	297.3	46.4	18.5%	2425	309.30
Dominica	529.4	683.2	153.8	29.1%	70	13.98
Dominican Rep.	762.8	927.7	165.0	21.6%	3925	585.68
Ecuador	453.8	520.1	66.3	14.6%	590	59.50
El Salvador	1472.3	1659.6	187.2	12.7%	713	62.52
Grenada	720.7	917.3	196.5	27.3%	106	19.99
Guatemala	1182.9	1307.7	124.8	10.6%	1028	74.82
Guyana	54.2	60.8	6.6	12.2%	45	3.81
Haiti	250.6	270.6	20.0	8.0%	170	9.34
Honduras	940.0	1020.0	80.0	8.5%	540	31.73
Jamaica	413.8	509.3	95.5	23.1%	2050	326.39
Mexico	3405.3	4250.1	844.8	24.8%	13750	2353.64
Nicaragua	578.8	613.8	35.1	6.1%	250	10.45
Panama	371.8	433.1	61.3	16.5%	1625	184.73

(continued)

Table 6. (continued)

	Predicted tourism With Disease Risk (thousands)	Predicted tourism without Disease Risk (thousands)	Tourism Increase (thousands)	Tourism Increase (%)	Tourist Expenditure (million US$)	Impact on Tourist Expenditure (million US$)
Paraguay	139.1	151.0	12.0	8.6%	114	6.77
Peru	608.3	717.6	109.3	18.0%	1900	235.46
St. Kitts & Nevis	778.2	1045.4	267.2	34.3%	123	29.02
St. Lucia	1214.6	1538.4	323.9	26.7%	320	58.88
St. Vicents & Gre.	969.5	1216.5	247.0	25.5%	104	18.28
Suriname	59.9	71.6	11.6	19.4%	91	12.12
Trinidad & Tobago	961.9	1233.9	271.9	28.3%	573	111.67
Venezuela	624.2	724.4	100.2	16.1%	908	100.54
Asia						
Bangladesh	431.6	461.8	30.2	7.0%	75	3.62
Brunei	477.4	646.6	169.2	35.4%	220	53.81
Cambodia	211.1	219.0	7.9	3.8%	1133	29.37
India	7439.7	8058.5	618.8	8.3%	9900	568.20
Indonesia	651.0	733.0	82.0	12.6%	6000	521.30
Lao	125.9	133.5	7.7	6.1%	193	8.08
Malaysia	3169.9	3681.2	511.3	16.1%	14750	1641.54
Pakistan	767.2	852.5	85.3	11.1%	913	70.01
Philippines	555.5	629.8	74.3	13.4%	3950	364.68
Sri Lanka	189.4	233.2	43.8	23.1%	753	119.98
Thailand	1794.4	2123.1	328.7	18.3%	18000	2274.83
Timor-Leste	33.5	36.0	2.5	7.6%	20	1.05
Vietnam	864.8	938.9	74.1	8.6%	3225	190.66
Oceania						
Palau	115.4	150.8	35.4	30.6%	63	13.32
Papua Nueva Guinea	48.9	52.8	3.9	7.9%	5	0.30
Solomon Islands	30.9	34.3	3.4	10.9%	25	1.90
Vanuatu	82.7	98.3	15.6	18.8%	135	17.55
Any disease affected countries						
Total	73 664.2	84 295.3	10 631.1	14.4%	120 460.2	11 995.45

an average growth of 3.7% in the affected destinations' inbound tourists.

At a secondary level, the eradication of Yellow Fever would lead to 8.1 million more tourists, representing an increase of 4975 million US dollars and a 30.1%% average growth in the tourist arrivals to affected economies. Finally, Ebola's eradication in the four affected countries during the period of our analysis would imply an increase of 5 million international tourists, representing an increase of 375 million US dollars and an average growth of 76%.

By analysing the economic benefits of the eradication of Dengue, Ebola, Malaria and Yellow Fever for the tourist sector—a strategic economic sector for many of the countries where these TRD are present—this paper explores a new aspect of the quantification of health policies which should be taken into consideration in future international health assessment programmes. Consequently, results of this work should be taken into account not only at international level to promote international research programs aiming the eradication of these diseases but also at country level to evaluate the economic benefits in terms of tourist expenditures for a specific country to reduce the incidence or eliminate the disease.

It is important to note that the results must be interpreted within the context of a study of these characteristics, and thus an analysis is only made of the direct impact of the diseases' eradication. The multiplicative effects of a growth in the GDP, in terms of tourism attractiveness, are not evaluated. Consequently, the economic results can be considered to be skeleton ones. Another important point is the fact that data at a national level was used for the analysis and this can be imprecise, especially in the case of some big countries where some of the aforementioned diseases tend to be limited to certain areas. However, tourism data is available at a national level and, for this reason, regional information could not be used.

Future research should try to take into account for neighbourhood effects (country with a high disease risk may negatively affect tourism in neighbouring countries) and to incorporate the latest available data, particularly in the case of Ebola, since it should be used to confirm whether the influence of the social media, following the 2014–2015 outbreak of Ebola, changed the impact on the affected countries. In particular to investigate the causal effect of the outbreak of some specific diseases (Ebola, SARS, ...) on tourism flows it would be desirable to use the difference in differences approach since these disease could have mainly a temporal effect. Moreover, this research only addresses the impact of infectious disease risk at the host country and tourist arrivals. However, the gravity model would make it possible to study the associations between tourism and disease risk in both the source and origin country since a disease in the origin country may prevent people from travelling abroad.

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Supplementary Data

Supplementary data are available at *HEAPOL* online.

Conflicts of interest statement: None declared.

Notes

1. Tourism data are collected from the United Nation World Tourism Organization. One of the main limitations of this database is that it does not report zero tourism flows between country pairs. Missing data can stem from gaps in the data collection procedure or because bilateral tourism flows between some country pairs are recorded only if they are above a certain threshold. Marginal tourism flows from origin countries to destinations are grouped together by the UNWTO under the "other countries" label. Although we recognize that estimates can suffer from sample selection bias, because zeros are not reported, only positive tourism flows are being considered in the analysis.
2. This variable is generated as $\text{ReligSim}_{\text{ij}} = \sum_{r=1}^{5} \boldsymbol{r_i r_j}$ where $\boldsymbol{r}_{\text{i}}$ and $\boldsymbol{r_j}$ are the percentages of the population affiliated to each of the five major religions in the origin and destination country, respectively. See Fourie *et al.* (2015) for variable definition.
3. The rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. This variable ranged from -2.5 (weak) to 2.5 (strong).
4. The average annual temperature for the period (1961–1990) is used since we are interested in climate not in weather.
5. Table S1 presents the source of the data.
6. For Malaria and Yellow Fever risk: http://www.who.int/ith/ITH_country_list.pdf.
7. For Malaria and Yellow Fever risk: http://wwwnc.cdc.gov/travel/yellowbook/2016/infectious-diseases-related-to-travel/yellow-fever-Malaria-information-by-country. For Dengue risk: http://wwwnc.cdc.gov/travel/yellowbook/2016/infectious-diseases-related-to-travel/DengueFor Ebola outbreaks: http://www.cdc.gov/vhf/Ebola/outbreaks/history/chronology.html.
8. Recommended prevention by the WHO is decided on the basis of the following factors: the risk of contracting Malaria; the prevailing species of Malaria parasites in the area; the level and spread of drug resistance reported from the country; and the possible risk of serious side-effects resulting from the use of the various prophylactic drug.
9. Based on surveillance data, official reports, published research, and expert opinion, compiled by CDC Dengue Branch in collaboration with University of Oxford.
10. WHO determines those areas where "a risk of Yellow Fever transmission is present" on the basis of the diagnosis of cases of Yellow Fever in humans and/or animals, the results of Yellow Fever zero-surveys and the presence of vectors and animal reservoirs. Yellow Fever vaccination is recommended for all travelers $\geq$9 months old in areas where there is evidence of persistent or periodic Yellow Fever virus transmission.
11. Note that since the dependent variable is in logarithm, the parameter of *DiseaseRisk* is interpreted as a semi-elasticity, that is Exp(γ)-1.
12. For simplicity in the counterfactual analysis is assumed that the TRD is completed eradicated (DiseaseRisk 0 for all countries).
13. Results of the simulation analysis are robust to alternative periods/years of reference.

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